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OFFICE OF NAVAL RESEARCH

FINAL REPORT

January 1, 1991 through December 31, 1992

for

Contract N00014-91-J-1896

R&T Code: 413e022

CORROSION CONTROL BY VITREOUS FILMS ON ALUMINUM
AND HIGH T_c SUPERCONDUCTORS

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- b. Cognizant ONR Scientific Officer: Mark Ross
- c. Telephone: 202-994-6934
- d. Description of Project

Electron spectroscopy has become one of our most important tools for the study of electronic structure of solids and at surfaces. A wide variety of electron spectroscopies have been developed over the years including photoelectron spectroscopy (PES, XPS and UPS), Auger electron spectroscopy (AES), x-ray emission spectroscopy (XES), electron energy loss spectroscopy (EELS), x-ray absorption spectroscopy (XAS), and others. These spectroscopic techniques provide unique capabilities for obtaining electronic structure and chemical information on surfaces and solids. Closely related to the Auger process is dissociative electron attachment (DEA), which on a surface, leads to electron stimulated desorption (ESD). These spectroscopies involve complicated dynamical many-body processes often making the spectra difficult to interpret. Our approach in ONR funded work over 10 years has been to understand these phenomena utilizing a semi-empirical theory to gain quantitative interpretations of electron spectral line shapes.

Under this contract, we studied the passivation and inhibition of corrosion, utilizing the spectroscopic techniques of XPS, AES, and NEXAFS. In particular, we studied the passivation of Al and Al-alloys towards attack by Cl^- , and the utility of Zr-Ir alloys to serve as diffusion/reaction barriers on silicon and carbon at elevated temperatures.

In addition we completed work, initiated under previous ONR contracts, namely, on the ESD of O^- from O_2 on condensed rare-gas surfaces. We also wrote some invited general review or tutorial papers on Auger line shape interpretation; work which has been previously funded by ONR over the years.

e. Significant Results

Table 1 summarizes our significant accomplishments in electron spectroscopy (AES, NEXAFS, and XPS), and in ESD/PSD. In each case, the table indicates the system studied, the significance of the work, and the numerical sequence (as indicated below) of the papers published (P), technical reports (TR) submitted, or manuscripts in preparation or submitted.

TABLE 1 - Review of Recent Accomplishments
(January 1991 - December, 1992)

SYSTEM	COLLABORATORS/ GW PERSONNEL	SIGNIFICANCE	PRODUCTIVITY (P, TR and M)*
1. Al/Al ₂ O ₃	Sambe Ramaker	First full understanding of the effects of the electrical double layer formed at Al/Al ₂ O ₃ interfaces on XPS and AES data.	P1 TR1
2. Al/Al ₂ O ₃	O'Grady(NRL)/ Ramaker Qian Jin	NEXAFS, XPS studies of aggressive Cl ⁻ ion on passive films of oxidized Al. Strong evidence for neutral Cl on Al ₂ O ₃ .	P2 M1
3. ZrIr/ Si,C	Sprague(NRL)/ Yang Gilmore Ramaker	AES, RBS, XPS, XRD study of ZrIr thin films as high temperature diffusion/reaction barriers.	TR7 M2, M3
4. O ₂ / Rare-gas	Sambe Ramaker	Det'm. of polarization, curve-crossings, and solid-state effects on desorption cross-section.	P3, P4, P5 TR3, TR4, TR5
5. Many systems	Ramaker	Invited reviews of previous ONR funded work on Auger line shape interpretation.	P6, TR2, TR6

*P, TR and M indicate sequence numbers of publications, ONR technical reports, and Manuscripts (either in preparation or submitted) as listed below.

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manuscripts (M) currently in preparation or submitted but not yet published.

f. Personnel Who Worked on Project.

1. Dr. Hideo Sambe - Research Associate Professor
Period worked: 10/1/91 - 11/30/92
Passivation of Al oxide films.
Dissociation/desorption of small molecules and negative ion desorption.
3. Mr. Hengxiang Yang - Graduate Student, summer support
Period worked: 9/1/91 - 10/30/92
Experimental study of Zr-Ir thin films.
4. Ms. Xinwei Jin - Graduate Student, summer support
Period worked: 1 summer month of 91.
Theoretical studies on NEXAFS data.
5. Ms. Xianghong Qian - Graduate student, summer support
Period worker: 1 summer month of 92.
Theoretical studies on NEXAFS data.
5. D. E. Ramaker - Principal Investigator
1 Summer month - July 1991 and 92

g. Publications emanating from contract.

1. "XPS Study on Electrical Double Layers at Al₂O₃-Al Interfaces", H. Sambe and D. E. Ramaker, J. Vac. Sci. Technol. A10, 2991 (1992).
2. "XAS Studies of Chloride on Aluminum", W.E. O'Grady, E. McCafferty, P.M. Natishan, A.E. Russell, K.I. Pandya, and D.E. Ramaker, Proc. Electrochemical Society, 91-2, 1163 (1992).
3. "The Role of Non-adiabatic Curve Crossings on the Yield in Dissociative Electron Attachment of Condensed O₂", H. Sambe and D.E. Ramaker, submitted to Desorption Induced by Electronic Transition, DIET V, ed. by E.B. Stechel and D.R. Jennison, Springer Series in Surface Sci., (Springer, Berlin Heidelberg, 1992).
4. "Resonance Electron Scattering by O₂ Monolayers on Graphite: Reinterpreted", H. Sambe and D.E. Ramaker, submitted to Desorption Induced by

Electronic Transition, DIET V, ed. by E.B. Stechel and D.R. Jennison, Springer Series in Surface Sci., (Springer, Berlin Heidelberg, 1992).

5. "Dissociative Electron Attachment of O₂: A Solid-State Effect on Potential Curve Crossings", H. Sambe and D.E. Ramaker, Surf. Sci. 269/270, 444 (1992).
6. "Auger Line Shapes as a Probe of Electronic Structure in Covalent Systems", D.E. Ramaker, Physica Scripta T41, 77 (1992).

Manuscripts in preparation or submitted but not yet published.

1. "Oxidation of Thin Film Engel-Brewer Compounds on Carbon", J.A. Sprague, C.M. Gilmore, H. Yang, C.R. Gossett, K.S. Grabowski, and D.E. Ramaker, submitted to Materials Science and Engineering.
2. "Ir-Zr Alloys as Diffusion Barriers Between Cu and Si(100)", J. Sprague, H. Yang, C.M. Gilmore, and D.E. Ramaker, accepted for publication in J. Vac. Sci. Technol.
3. "The Uptake of Cl by a Passivated Al Electrode as Indicated by X-ray Absorption Spectroscopy", W.E. O'Grady, E. McCafferty, P.M. Natishan, A.E. Russell, K.I. Pandya, and D.E. Ramaker, manuscript in preparation.

h. Technical Reports Issued

1. "XPS Study on Electrical Double Layers at Al₂O₃-Al Interfaces", H. Sambe and D.E. Ramaker, ONR Technical Report, 1992; ONRGWU # 59.
2. "Auger Line Shapes as a Probe of Electronic Structure in Covalent Systems", D.E. Ramaker, ONR Technical Report, 1992; ONRGWU # 60
3. "Dissociative Electron Attachment of O₂: A Solid-State Effect on Potential Curve Crossings", H. Sambe and D.E. Ramaker, ONR Technical Report, 1992; ONRGWU # 61

Condensed O₂",
H. Sambe and D.E. Ramaker,
ONR Technical Report, 1993; ONRGWU # 62

5. "Resonance Electron Scattering by O₂ Monolayers on Graphite: Reinterpreted",
H. Sambe and D.E. Ramaker,
ONR Technical Report, 1993; ONRGWU # 63.
6. "Accurate Determination of Auger Line Shape Reference Points",
N.H. Turner, D.E. Ramaker, and F.L. Hutson,
ONR Technical Report, 1993; ONRGWU # 64.
7. "Ir-Zr Alloys as Diffusion Barriers Between Cu and Si(100)",
H. Yang, C.M. Gilmore, and D.E. Ramaker,
ONR Technical Report, 1993; ONRGWU # 65.

